Terrestrial Water Storage: Implications of the Decadal Survey

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Overview

- Key questions
- What do we know, what can we do now?
- Does the Survey support our priorities?

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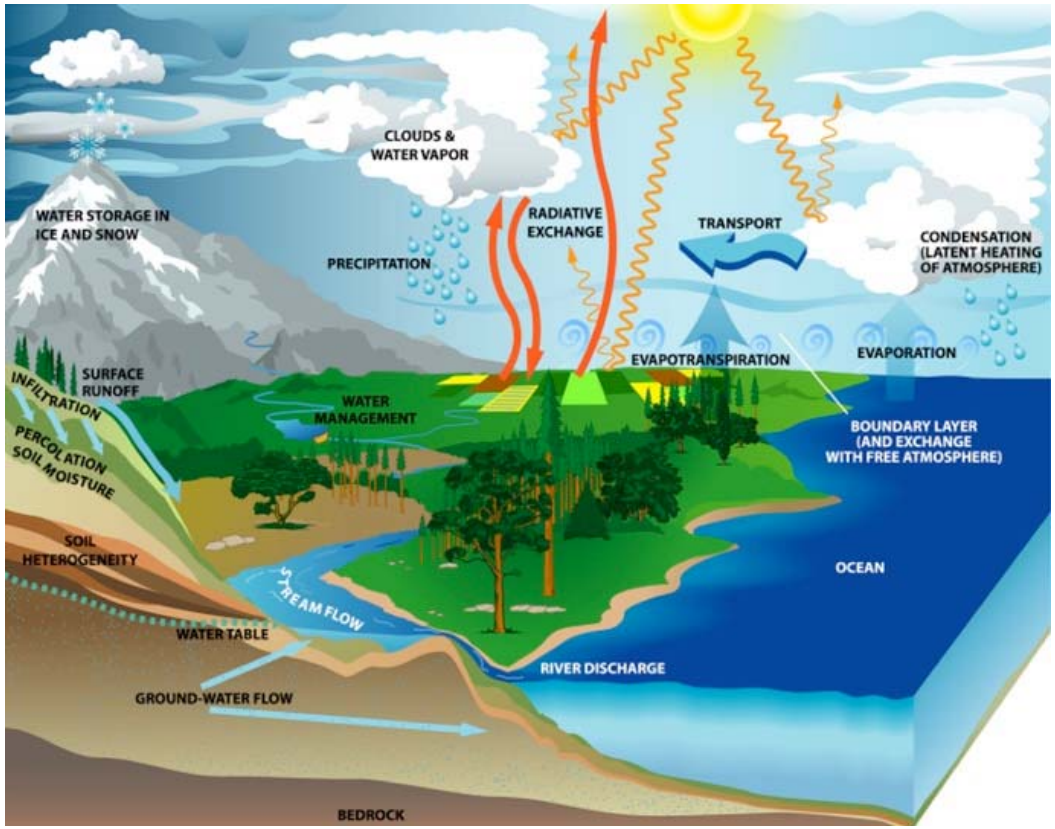
Key questions:

- **How much water is on land?**
- **How is it distributed laterally and vertically?**
  - **How is it partitioned among snow, ice, surface water, soil moisture, groundwater?**
- **What are the variations and trends?**
- **What is the role of water management?**

How much water is on land?



How much water is on land?

- **In global balances, e.g. Chahine, Oki, Trenberth, etc., where do the land numbers come from?**
- **What is their uncertainty?**
- **How can remote sensing contribute?**

  Snow water equivalent, snow extent; alpine glaciers; permafrost; surface water; soil moisture; groundwater; total water storage

- **What are the *in situ*, dataset and modeling needs?**

  More in situ and deeper soil moisture sensors; more groundwater monitoring wells; groundwater in land surface models; global wetland/floodplain maps; global depth to bedrock maps; global, model friendly aquifer maps; climatology of groundwater levels

How is it distributed laterally and vertically?

- **How can remote sensing contribute?**

  Snow water equivalent, snow extent; alpine glaciers; permafrost; surface water; soil moisture; groundwater; total water storage

- **Need continuous time series and assimilation or model inversion**

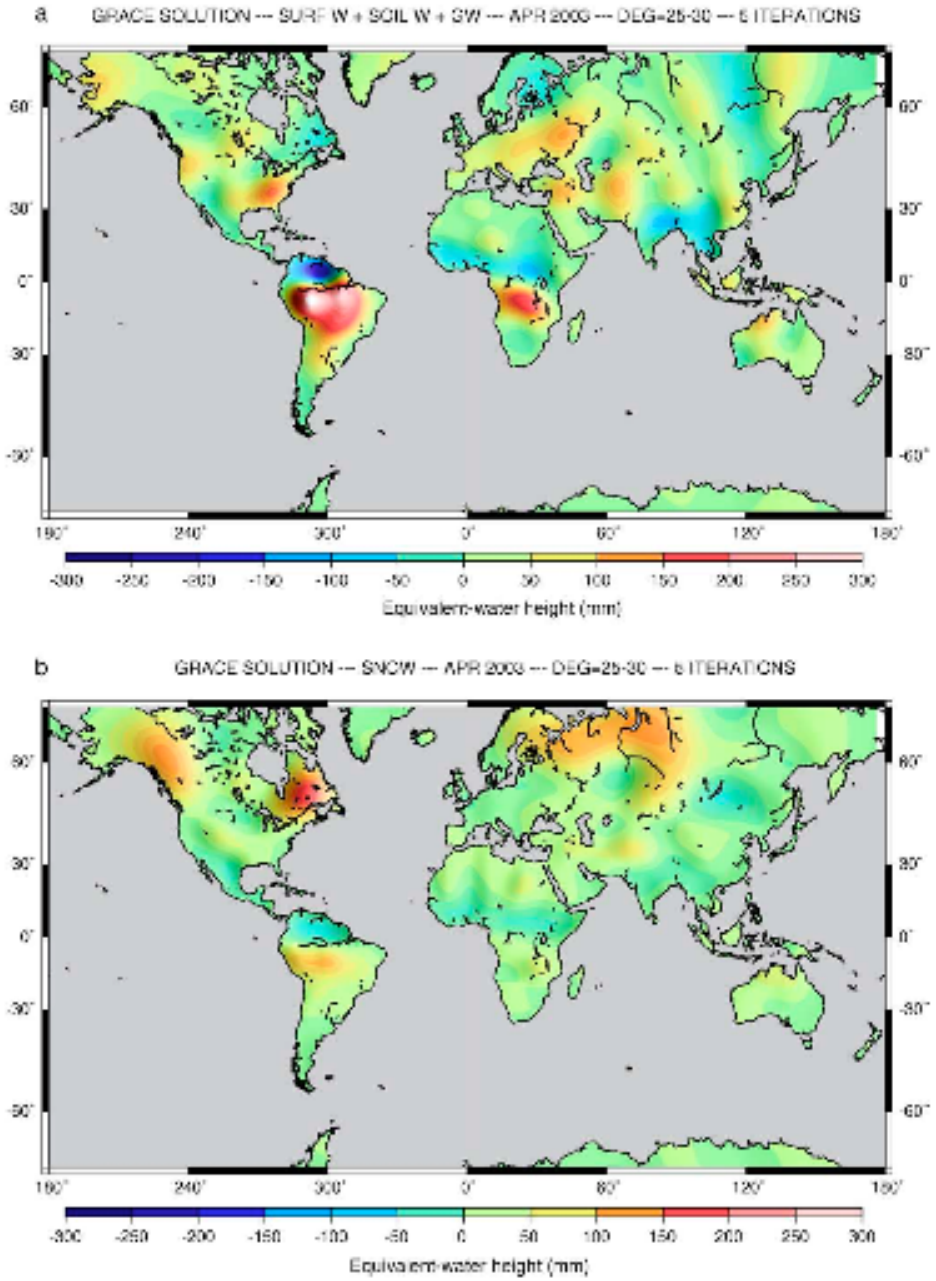
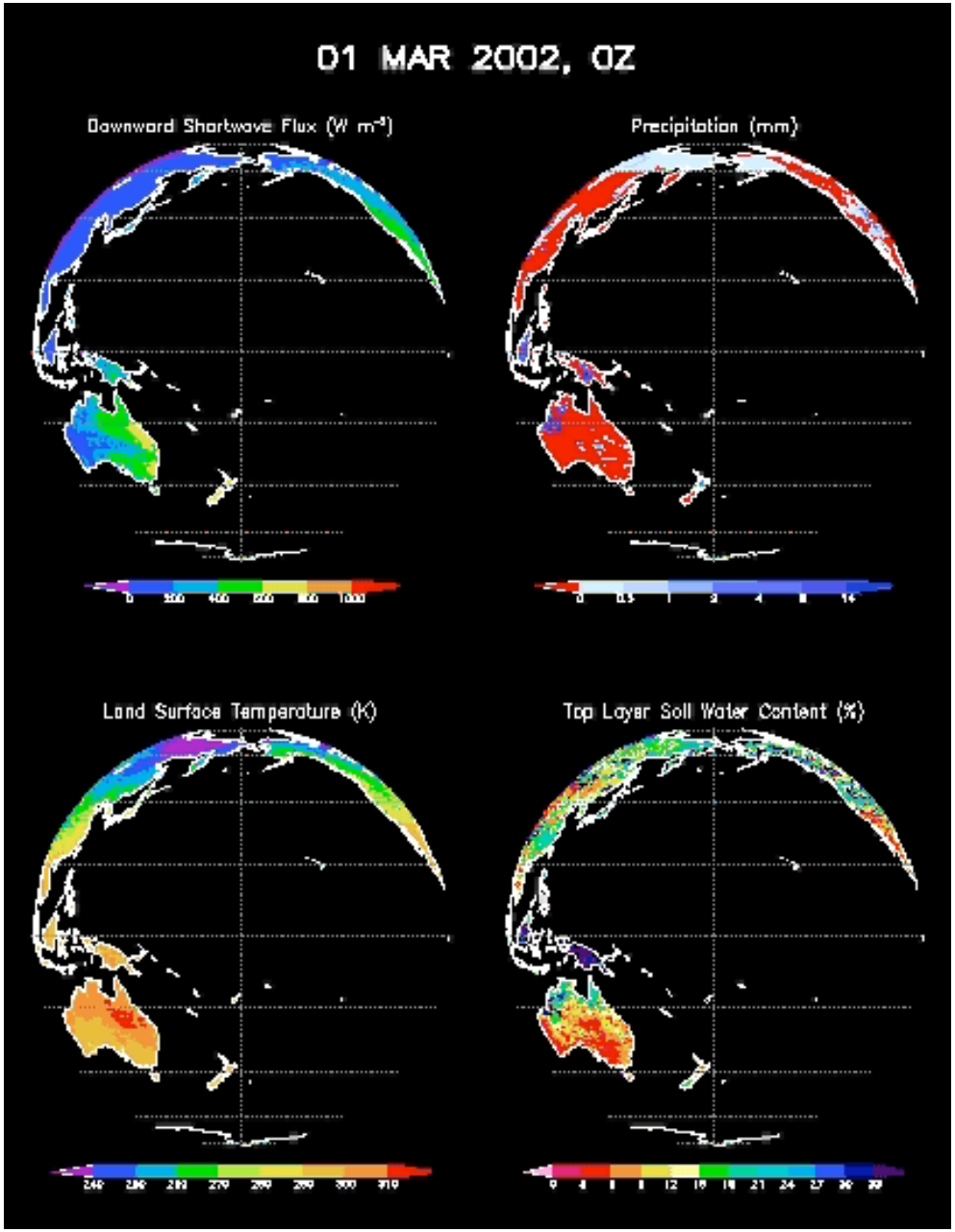


Fig. 3. Example of an efficient separation of hydrological components for April 2003 (5-iteration solutions, degree maximum 25–30): (a) total (liquid) water solution (surface waters + soil moisture + groundwater) and (b) snow depth solution.

Ramillien et al., 2005



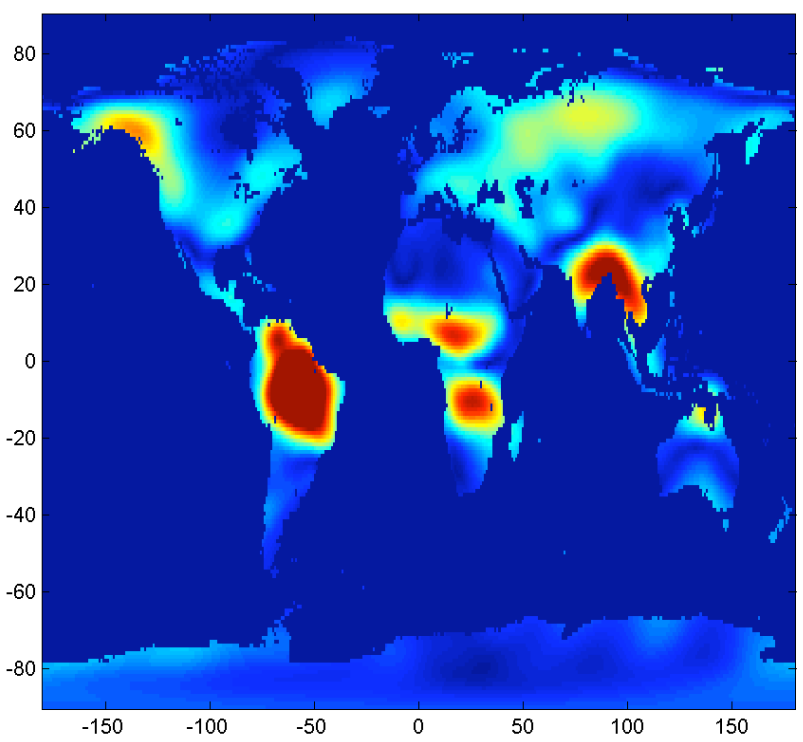
Rodell et al., 2004

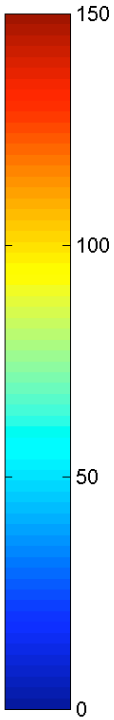
What are the variations and trends?

- Can do for total water storage using GRACE, but…
- Are the Survey recommendations sufficient to accomplish this for snow, ice, surface water, soil moisture and groundwater?

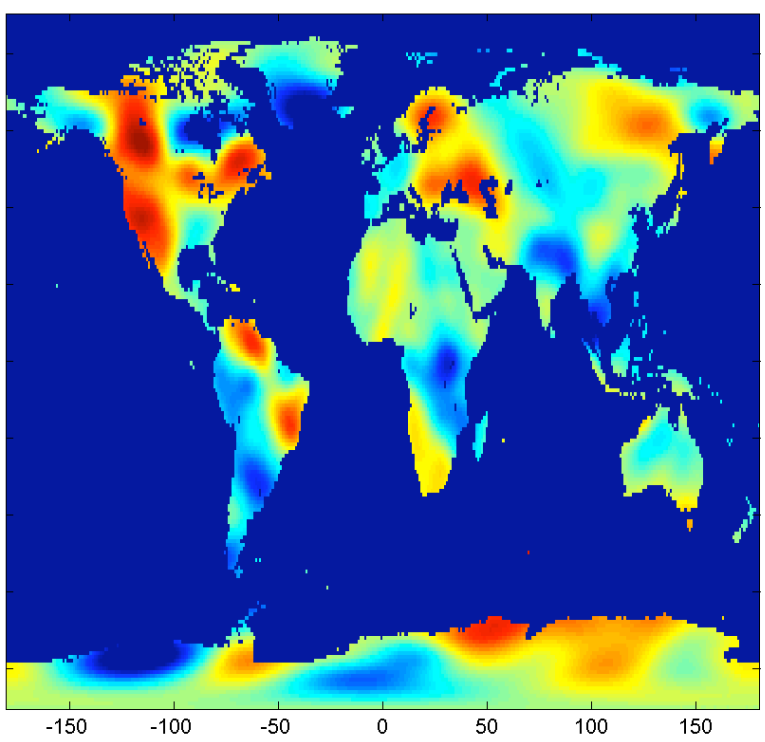
Land: “Interannual variations and trends”

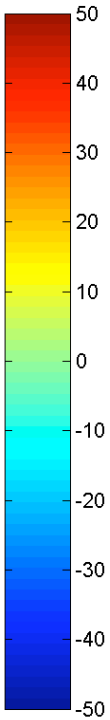
Annual Amplitude (mm)





Trend (mm/yr)





- GFZ_RL03 “de-striped” grids
- 500 km smoothing

Role of GRACE

- As time series lengthen, we are beginning to see the interannual variations and trends
- Since GRACE monitors changes in water storage, it enables water balance closure at multiple scales, e.g. global, continental, large river basin
- Can solve water balance for unknowns such as

  Evapotranspiration (Rodell et al, 2004; Ramillien et al., 2006)

  P-E (Swenson and Wahr, 2006; Liu et al., 2006)

  Discharge (Syed et al., 2005, 2007)

  Groundwater storage changes (Rodell et al., 2006; Swenson et al., 2006,2007; Yeh et al., 2006)

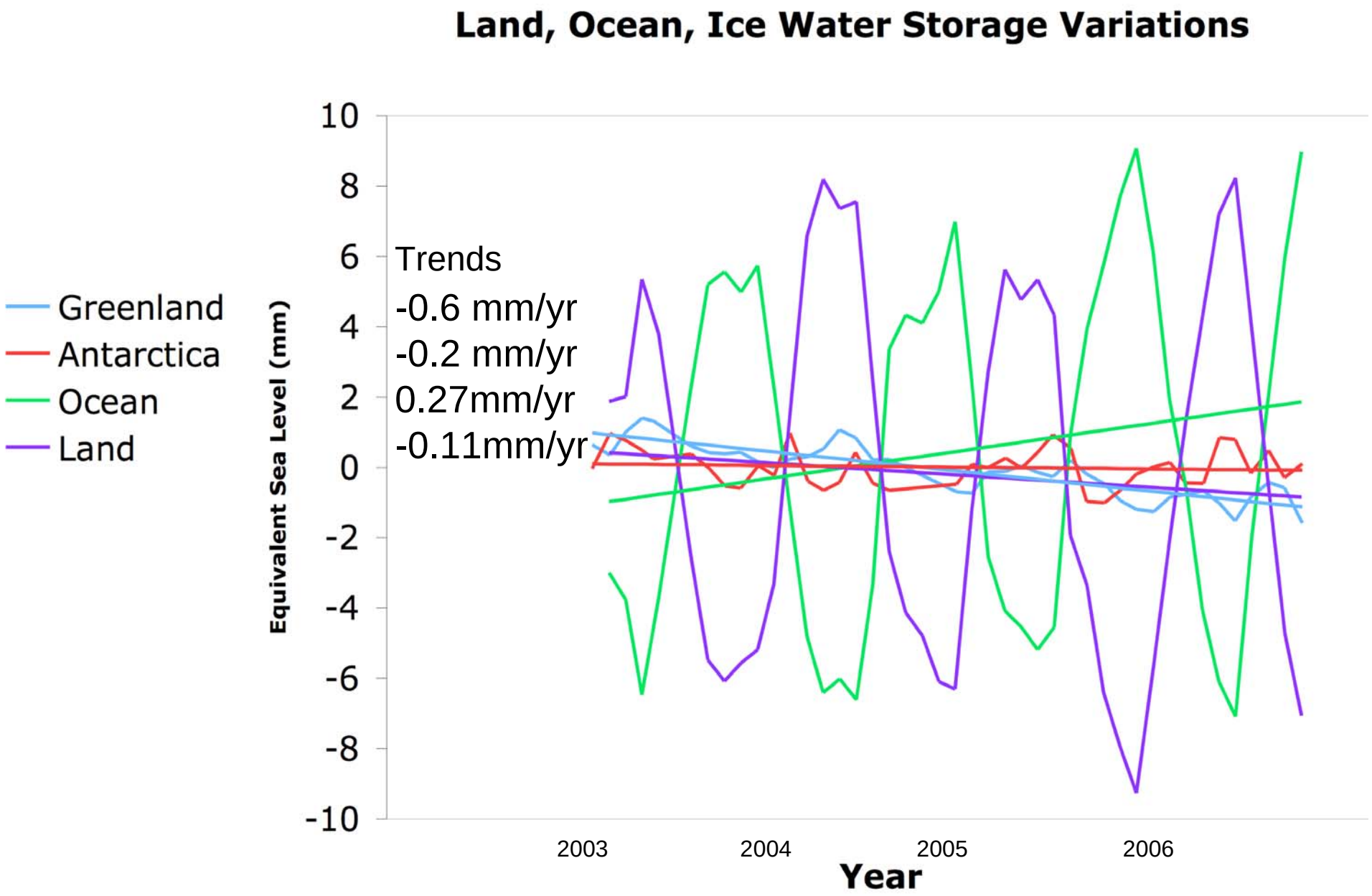
  Ice sheet mass loss (Velicogna and Wahr, 2006a,b)

Closing comments

Need to begin to assemble a modern picture of terrestrial water storage including its lateral and vertical distribution, variations and trends

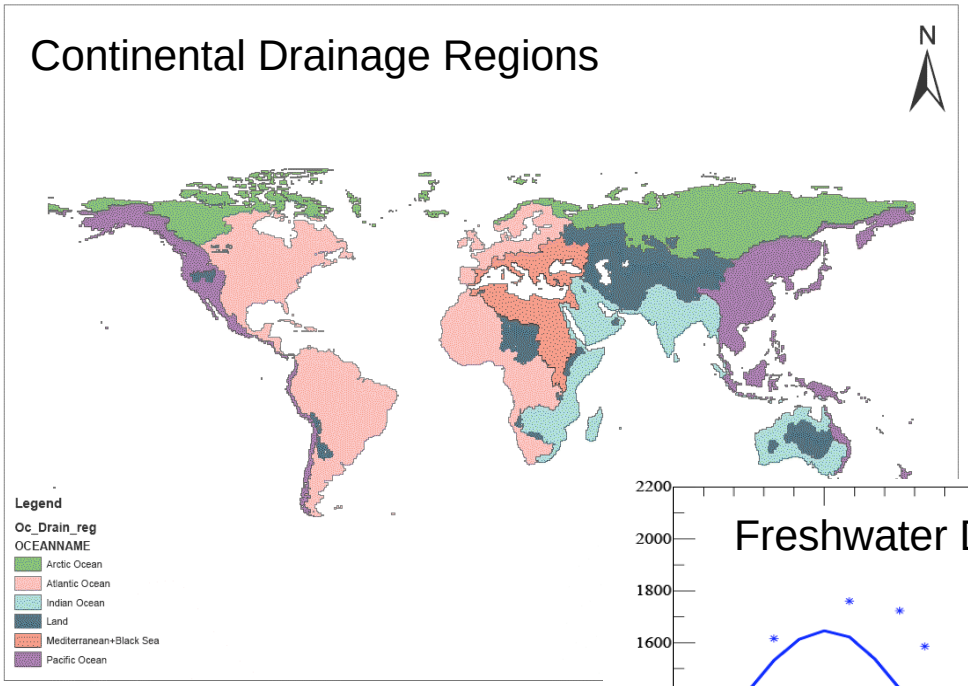
Need better integration between terrestrial hydrology and cryosphere communities for alpine glaciers and permafrost changes

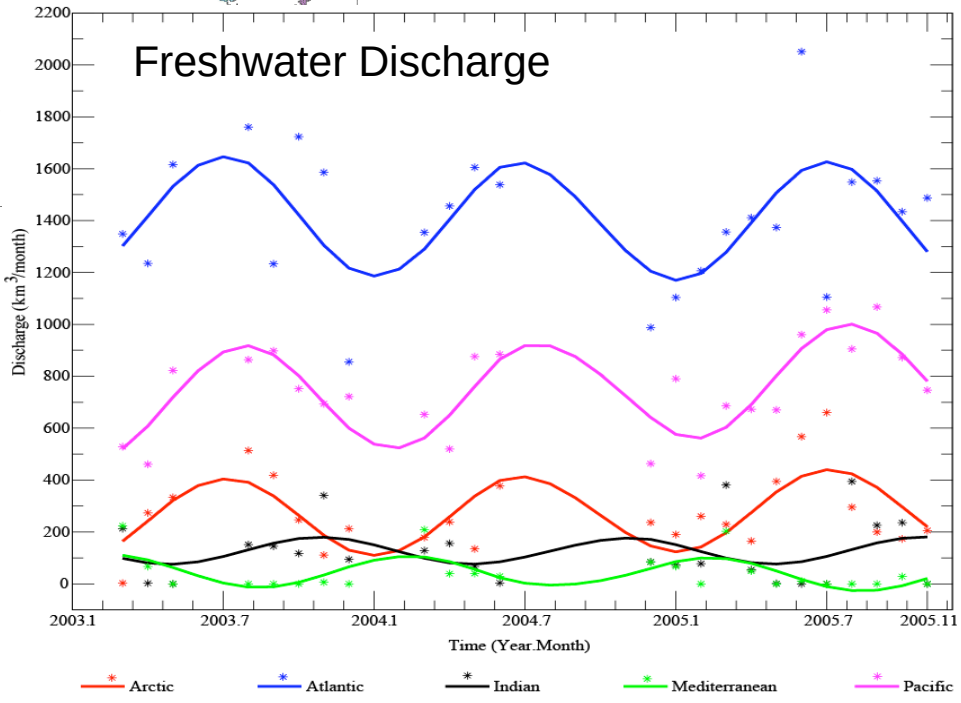
Are the Survey recommendations sufficient to accomplish these goals?


Land, Ocean, Ice Water Storage Variations
Greenland
Antarctica
Ocean
Land
Trends
-0.6 mm/yr
-0.2 mm/yr
0.27mm/yr
-0.11mm/yr
Equivalent Sea Level (mm)
10
8
6
4
2
0
-2
-4
-6
-8
-10
2003
2004
2005
2006
Year

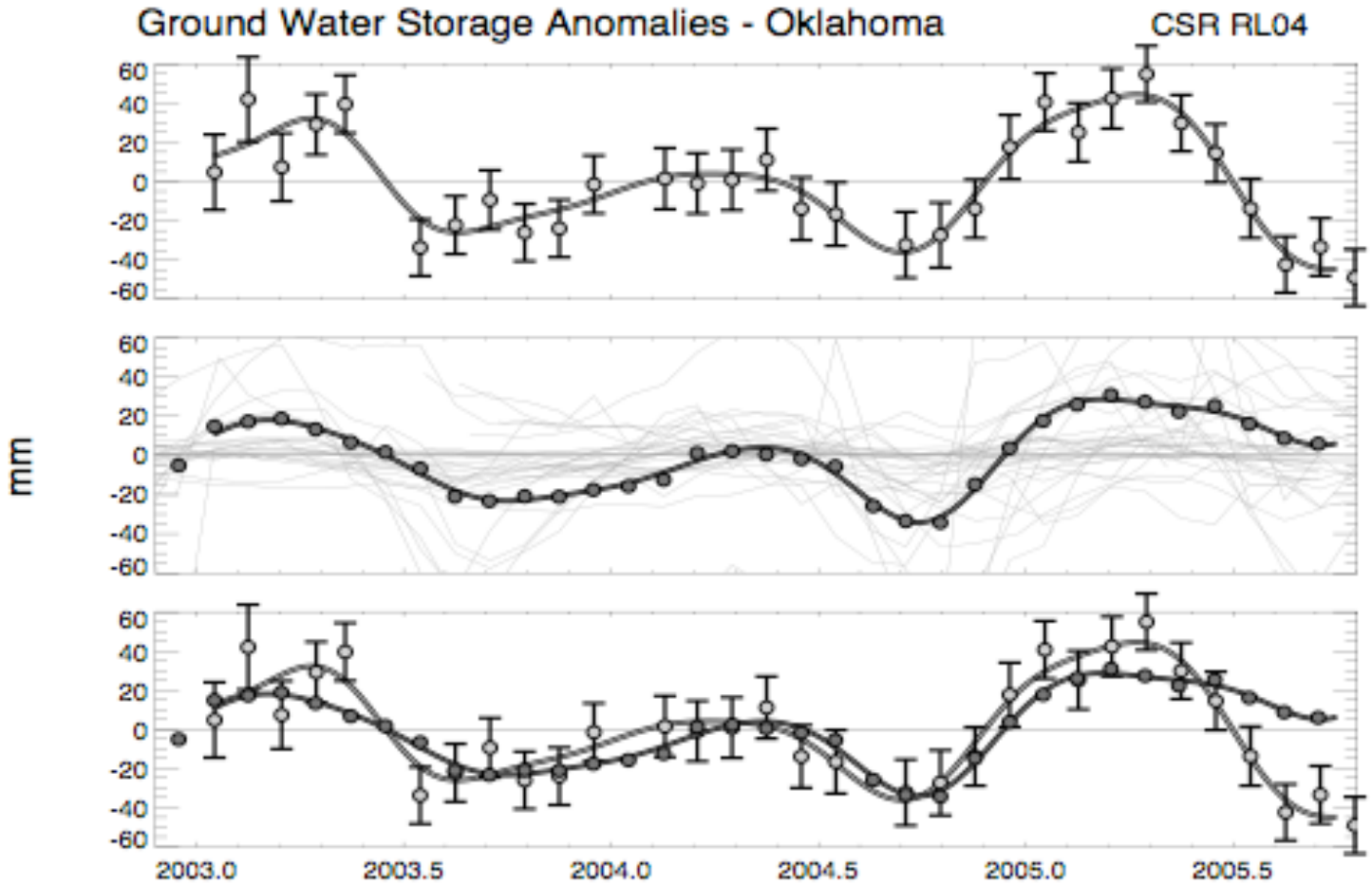
Estimating Freshwater Discharge into the Oceans:

$Q = P - E - \Delta S$





Groundwater storage changes



Swenson et al., 2007